# Identification of a high-risk population for esophageal injury during radiofrequency catheter ablation of atrial fibrillation: Procedural and anatomical considerations

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**BACKGROUND** Atrioesophageal fistula is an uncommon but life-threatening complication of atrial fibrillation (AF) ablation. Esophageal ulcerations (ESUL) have been proposed to be potential precursor lesions.

**OBJECTIVE** The purpose of our study was to prospectively investigate the incidence of ESUL in a large patient population undergoing radiofrequency catheter ablation (RFA). Additionally, we aimed to link demographic data and lesion sets with anatomical information given by multislice computed tomography imaging and to correlate these data with the development of ESUL.

**METHODS** This study included 267 patients and consecutively screened all individuals for evidence of ESUL 24 h after RFA of AF by endoscopy of the esophagus. A standardized ablation approach using a 25-W energy maximum at the posterior left atrial (LA) wall without esophagus visualization, temperature monitoring, or intracardiac ultrasound was performed.

**RESULTS** In total, we found 2.2% of patients (6 of 267) presenting with ESUL. Parameters exposing a specific patient to risk of developing ESUL in univariate analysis were persistent AF (5 of 95, $P = .023$), additional lines performed (roofline: 6 of 114, $P = .006$; LA isthmus: 4 of 49, $P = .011$; coronary sinus: 5 of 66, $P = .004$), and LA enlargement ($P = .001$) leading to sandwiching of the esophagus between the LA and thoracic spine. Multivariate analysis revealed LA-to-esophagus distance as the only significant risk factor.

**CONCLUSION** This study is the first to link anatomical information and procedural considerations to the development of ESUL in radiofrequency ablation for AF. Furthermore, it reveals the correlation and individual impact of these factors. Not a single patient with pulmonary vein isolation alone developed ESUL.

**KEYWORDS** Atrial fibrillation; Radiofrequency catheter ablation; Esophageal injury; Atrioesophageal fistula; Endoscopy; Complications; Multislice computed tomography

**ABBREVIATIONS** **AF** = atrial fibrillation; **CS** = coronary sinus; **ESUL** = esophageal ulcerations; **ICE** = intracardiac echocardiography; **LA** = left atrium/atrial; **LET** = luminal esophageal temperature; **MSCT** = multislice computed tomography; **OIT** = open irrigated tip; **PPI** = proton pump inhibitor; **PV** = pulmonary vein; **RF** = radiofrequency; **RFA** = radiofrequency catheter ablation

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## Introduction

Radiofrequency catheter ablation (RFA) as a potentially curative approach to treat highly symptomatic and drug-refractory atrial fibrillation (AF) has become a widely used procedure already included into the American College of Cardiology/American Heart Association/European Society of Cardiology 2006 Guidelines for the Management of Patients with AF.[1] As a very rare but potentially life threatening complication, atrioesophageal fistulae have been reported.[2,3] These shortcuts between left atrium (LA) and esophagus presumably emerge from radiofrequency (RF) energy delivery at the LA posterior wall and thermal injury to the adjacent esophagus by conductive heating. Esophageal ulcerations (ESUL) were reported as potential precursor lesions of these fistulae.[4–9] From a first randomized study published on this topic (175 patients), we identified possible risk factors for the development of ESUL, namely additional LA linear lesions, maximum energy delivered at the posterior wall, and nasogastric tubes used for visualization of the esophageal course.[9] Beginning with these possible risk factors, we aimed to evaluate the individual impact of various additional linear lesions on the development of ESUL in a standardized ablation approach using a 25-W energy maximum at the posterior LA wall. Additionally, we wanted to link anatomical information gained by multislice computed

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tomography (MSCT) with the end point of ESUL, as no study has yet done. No temperature monitoring, active cooling, intracardiac ultrasound (ICE), or visualization of the esophageal course were used as no studies have consistently shown the superiority of these strategies over a standard approach to date.[4–10]

## Methods

### Study design

The study population consisted of 275 consecutive patients presenting to the Elisabethinen University Teaching Hospital Linz for pulmonary vein (PV) isolation from September 2007 to June 2009. All patients gave informed consent; the study was approved by the local ethics committee. Patients refusing to have endoscopy of the esophagus performed the day after the procedure were excluded (n = 8). Table 1 lists the demographic data of all study patients.

To analyze the pure effect of additional LA lesions and patients' anatomy on ESUL development without influence of procedural factors such as maximum energy, ablation catheters used, or esophageal visualization, all patients were treated with 1 single standardized RFA approach: RF energy maximum of 25 W at the posterior LA wall, single lesion duration up to 30 s, 3.5-mm open-irrigated-tip (OIT) catheters. The performing electrophysiologist was blinded to the esophageal course as well as MSCT anatomical measurements, thus preventing modification of the RFA lines at the posterior wall. As this is the standard RFA approach of our laboratory, we could expect a success rate similar to that of previous reports.[9,11]

### Ablation procedure

All RFA were performed using a 3-dimensional electroanatomic mapping system with MSCT integration (CartoMerge, Biosense Webster, Diamond Bar, California, in 47.8% of cases or NavX, St. Jude Medical, St. Paul, Minnesota, in 52.2% of cases).[11,12] Using a transfemoral venous approach, a multipolar catheter was placed in the coronary sinus (CS). Next a transseptal puncture with subsequent retrograde angiography of the PV was performed. For mapping and ablation, a 3.5-mm OIT quadripolar catheter (Navistar Thermocool 7-Fr, Biosense Webster, or Therapy Cool Path, Irvine Biomedical, Irvine, California) was used. To evaluate electrical disconnection between the LA and the PV, a ring-shaped multipolar diagnostic catheter (Lasso, Biosense Webster, or Inquiry Optima, Irvine Biomedical) was introduced into the different PVs.

Our technique was to perform LA circumferential ablation[13] with the addition of further linear lesions[14] (roof line between the left and right superior PV, mitral isthmus line between the left inferior PV and the mitral valve annulus, endocardial and epicardial ablations to disconnect the CS, and inferior line starting from the posterior septum next to the right inferior PV, dragging along the CS to a lateral position next to the left inferior LA) and focal RF applications at areas showing complex fragmented atrial electrograms (as depicted by an automated dedicated software of the Carto or NavX system).[15] PV isolation lines were created approximately 1 cm away from the tubular ostium at the posterior aspect and anterior right PVs as well as at the ostium at the anterior aspect of the left superior PV. The 2 lesion sets encircling the left and right veins were at least 2 to 3 cm apart at the posterior LA wall.

Lines and complex fragmented atrial electrogram ablations were performed only if AF could not be terminated by PV isolation alone or still was inducible after PV isolation. In these cases, the second step after PV isolation was roofline ablation; the order of additional ablation steps was the operators' decision. End points were PV disconnection (assessed by entrance block) in paroxysmal AF as well as termination of AF in persistent cases (either accomplished by RFA alone or conversion to atrial tachycardia and electrical cardioversion). Induction was performed by atrial burst pacing down to atrial refractoriness or isoproterenol infusion titrated up to a heart rate of 140 beats/min.

The following hardware settings were used: maximum temperature 43°C; 25 W energy delivered at the posterior wall, 20 W in the CS, and 30 W in all other locations; irrigation flow rate 17 to 30 ml/min; and no titration of energy. All patients were on uninterrupted coumadin at least 4 weeks prior to the procedure and 3 months thereafter. Target international normalized ratio for RFA was 2.0, and patients additionally received heparin intravenously, with an activated clotting time between 300 and 400 s during the ablation procedure.

Deep sedation was used as the standard approach in most of the patients; general anesthesia was performed at patient preference, in patients getting increasingly agitated during deep sedation, or in those presenting with a sleep apnea condition.

### Endoscopy and endosonography of the esophagus

Endoscopy was performed in every patient the day after the RFA procedure. Special emphasis was laid on the esophageal wall, and abnormalities were documented. ESUL were de-

**Table 1** Patient characteristics

| | Esophageal ulceration | | |
|---|---|---|---|
| | No | Yes | *P* value |
| Number of patients | 261 | 6 | |
| Demographic information | | | |
| Male, % | 80.1 | 66.6 | .350 |
| Age, mean ± SD | 57.6 ± 9.2 | 61.7 ± 4.5 | .286 |
| Weight, mean ± SD | 86.2 ± 13.5 | 80.2 ± 12.2 | .323 |
| Disease characteristics | | | |
| Structural heart disease, % | 21.8 | 33.3 | .616 |
| Arterial hypertension, % | 42.9 | 33.3 | .639 |
| Diabetes mellitus, % | 6.5 | 16.7 | .345 |
| Persistent atrial fibrillation, % | 34.5 | 83.3 | .023 |
| Antiarrhythmic drugs failed | 2.6 ± 1.6 | 2.5 ± 1.4 | .874 |
| Procedural characteristics | | | |
| First ablation procedure, % | 73.2 | 50.0 | .147 |
| General anesthesia, % | 14.2 | 16.7 | .863 |
| Duration of fluoroscopy | 43.4 ± 19.1 | 50.3 ± 10.1 | .532 |
| Duration of procedure in minutes | 225 ± 60 | 219 ± 18 | .871 |